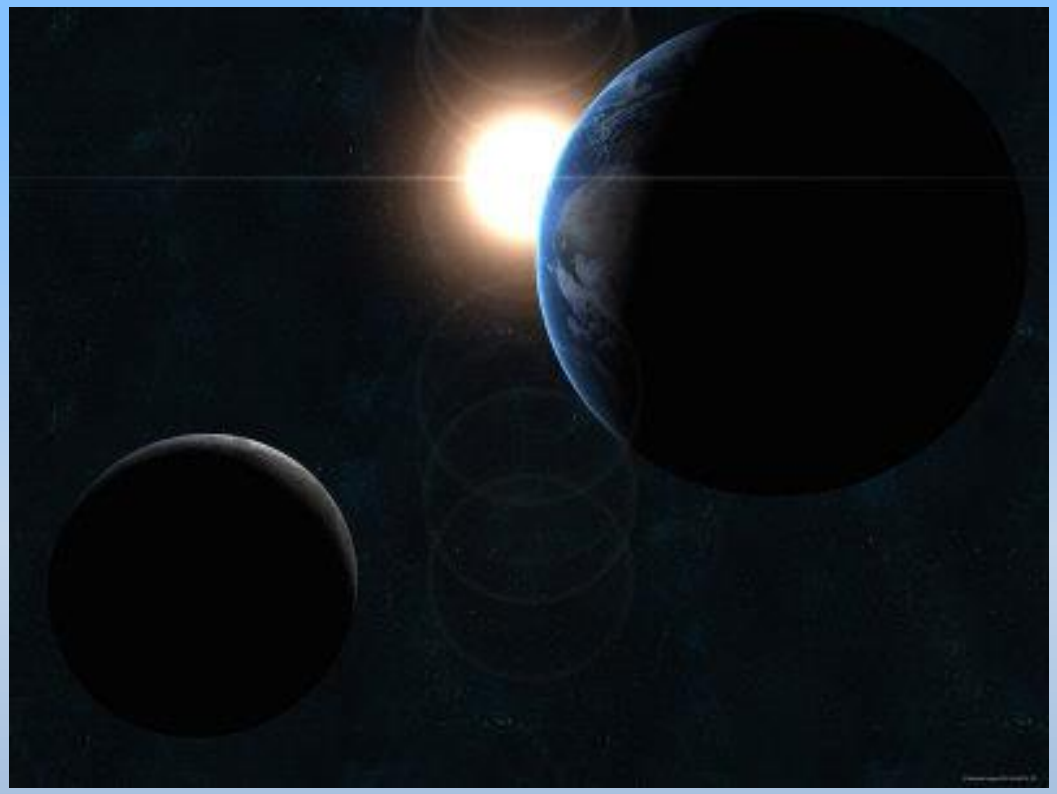
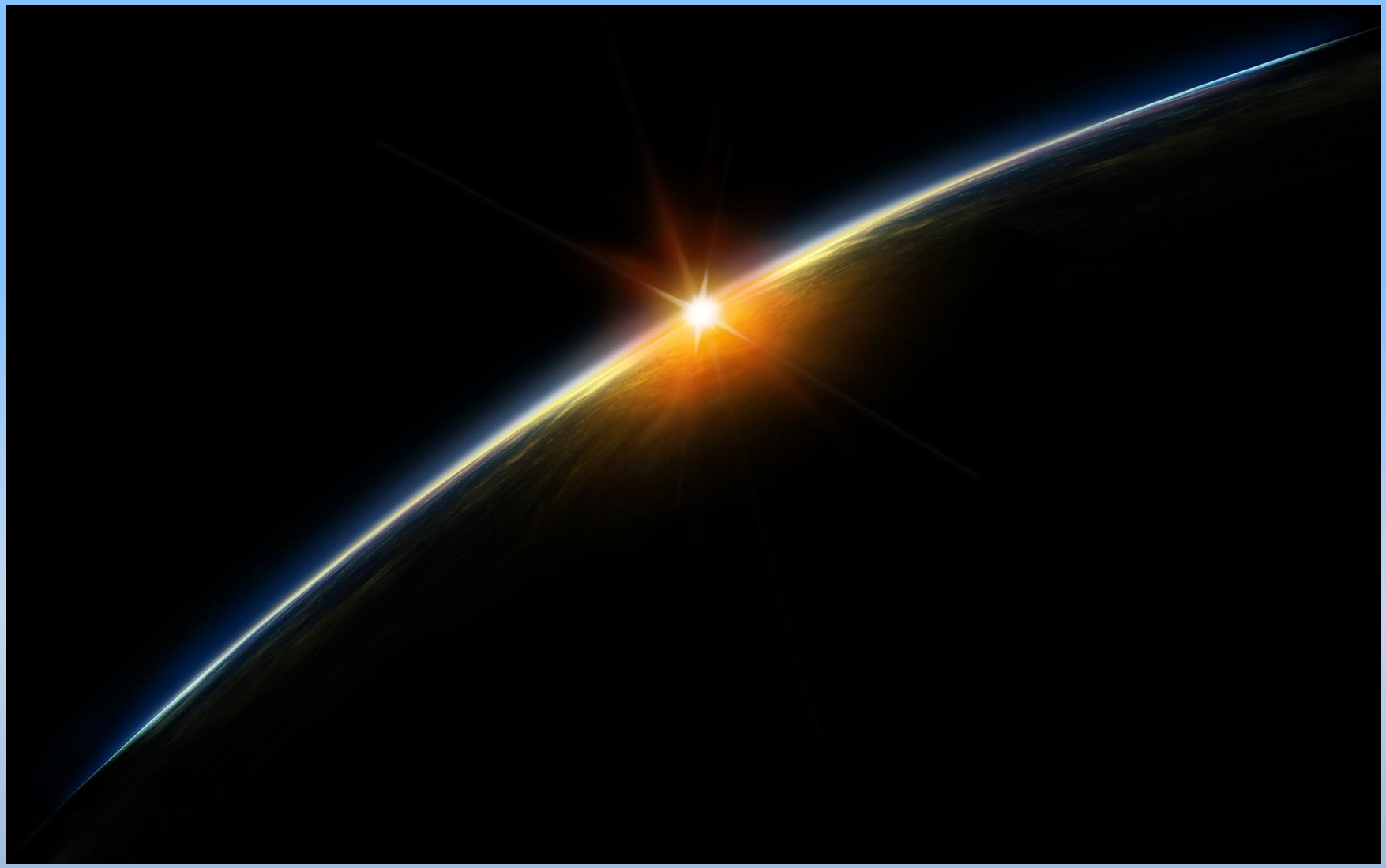
Earth Moon Sun System



Earth's Motions!



Rotation

- Turning or spinning of a body on its axis.
- Earth's axis is tilted 23.5° from the ecliptic (plane of Earth's orbit around the Sun, and is the apparent path of the Sun throughout the year) {Earth's tilt varies from 21.5° - 24.5°, this is known as *"obliquity"* 41k yr. cycle}
- Rate of rotation is once per 24 hour period, but speed or rotation varies depending on location on Earth (speed = dist./time) Speed at the equator = 1035mi/hr!

Rotation

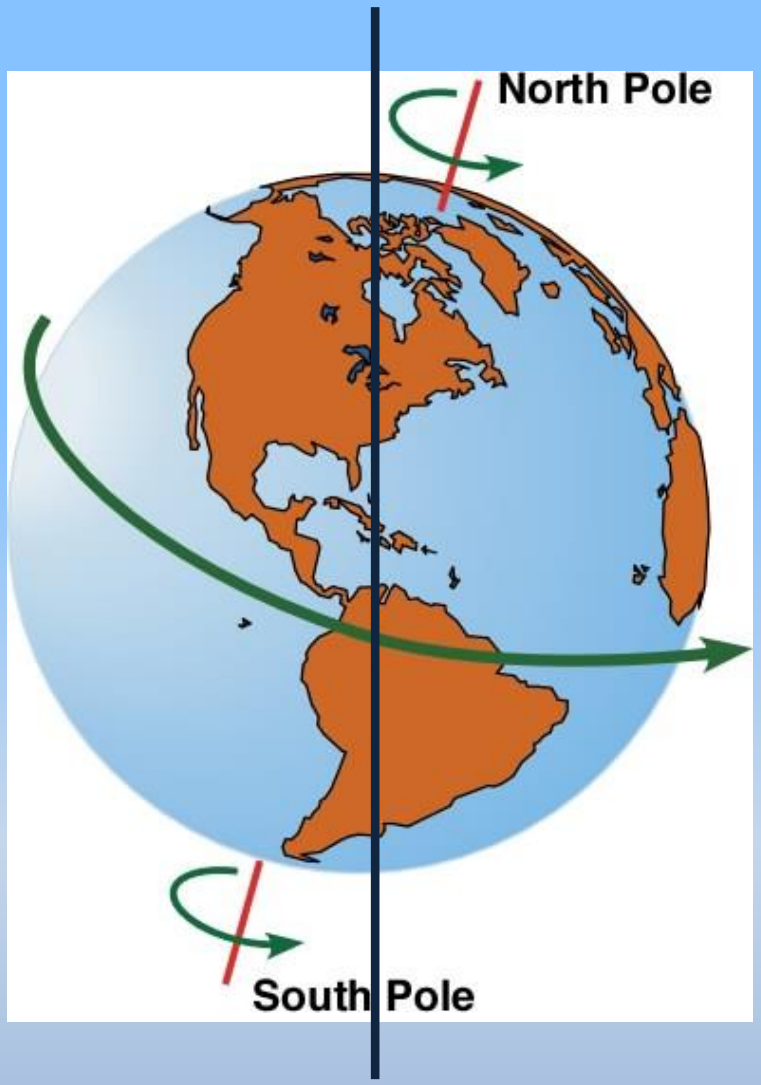
- Results in *diurnal motion* (the daily rising and setting of things in the sky.)
- Period of rotation can be measured in two ways:

  -Solar Day: relative to the Sun, when the Sun returns to its original position in the sky (when a position on Earth realigns with the Sun – *24 hours*

  -Sidereal Day: relative to distant stars, when a star other than the Sun returns to its original position in the night sky (when a position on Earth realigns with a star other than the Sun) – *23hr. 56min. 4sec.*
- *Earthquakes* can affect the rotation of Earth*

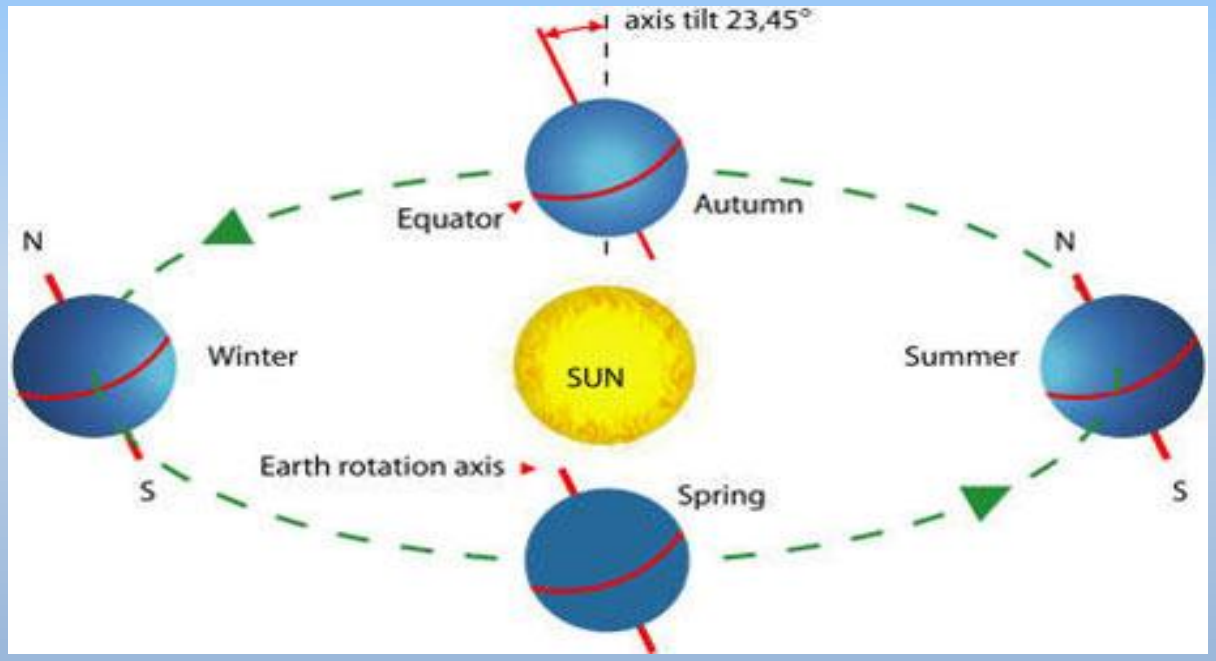
Rotation

- West to East
- Fast near equator, slow near poles
- Rotation seems to be a product of gravitational forces and angular momentum*



Revolution

- The motion of a body along its orbit around some point in space.
- Earth revolves around the Sun, once/yr., in an elliptical orbit at an avg. speed of 66,500 mi/hr. (875 yrs. @ 80mi/hr.!)
- Orbital shape varies – "*eccentricity*" changes from nearly circular to more elliptical over many hundreds of thousands of years.



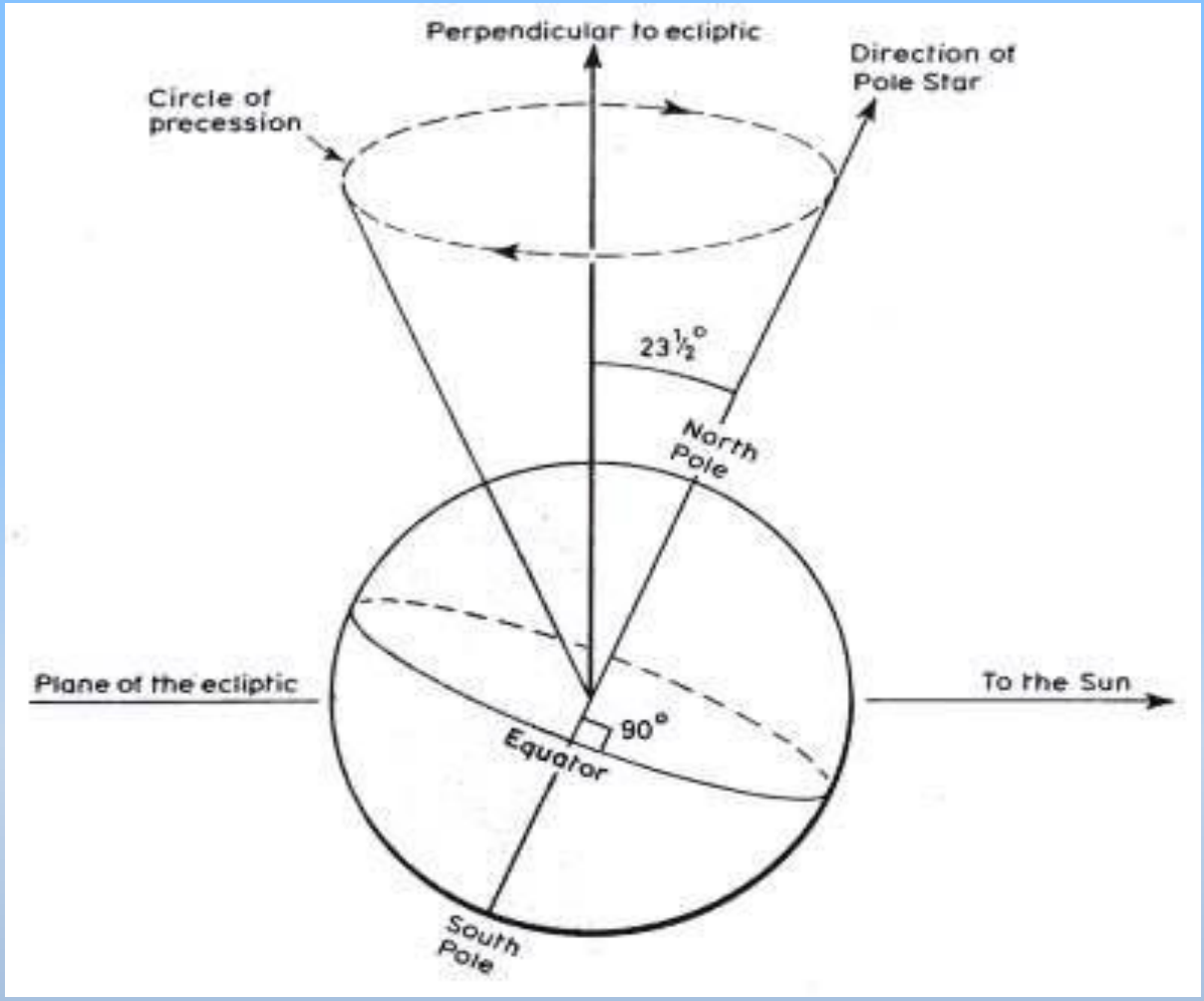
Revolution

- Distance from Sun varies throughout year:
  - Perihileon: Pt. at which E is closest to Sun (~Jan 3)
  - Aphelion: Pt at which E is furthest from Sun (~July 4)
- *Distance from Sun does NOT cause seasons
  - Seasons are caused by the amount of energy a hemisphere receives in a given 24hr. period which varies b/c of E's tilted axis and revolution (pgs. 481-482)
- Revolution also results in the two hemispheres experiencing *seasonal constellations*.

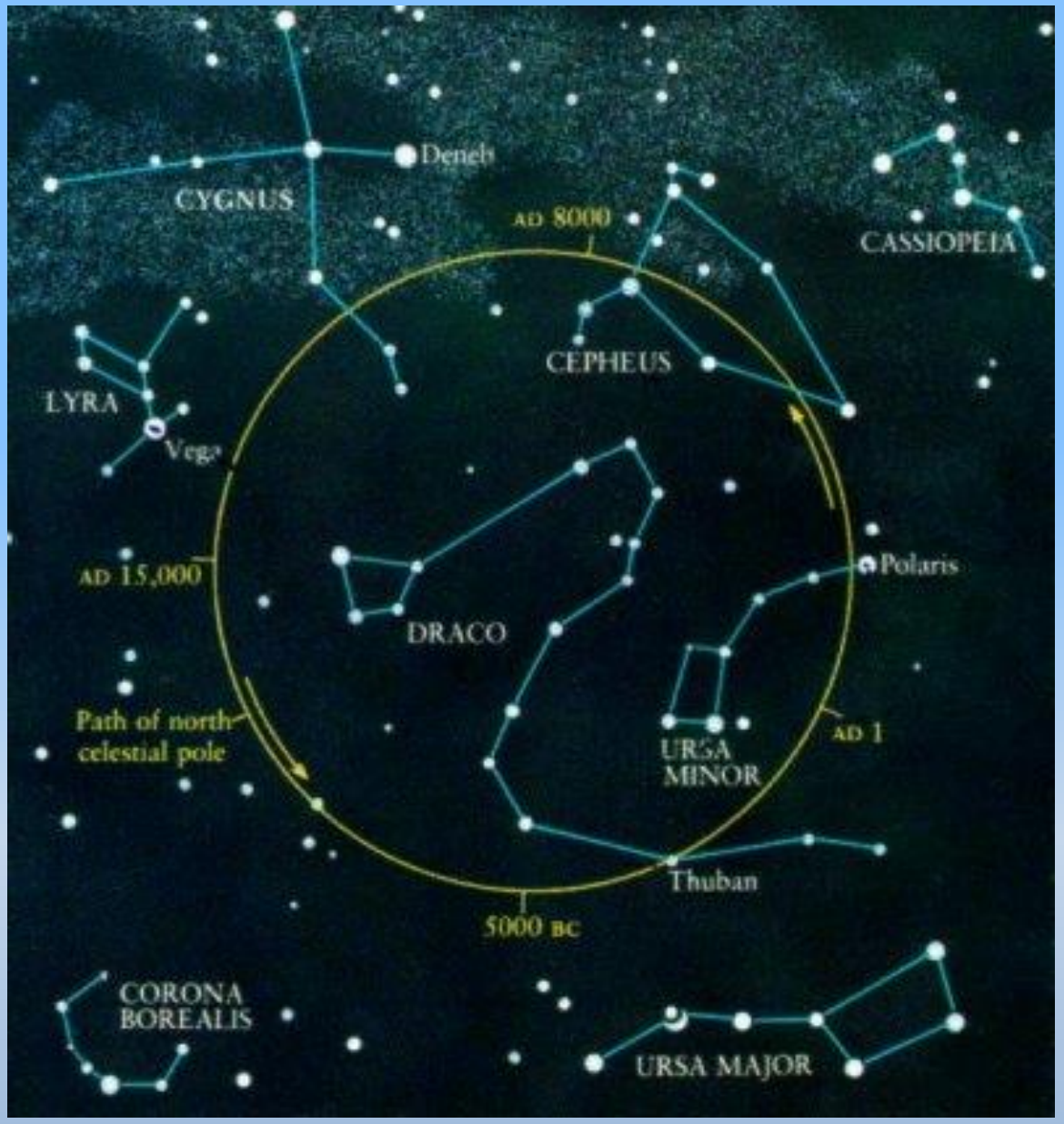
Precession

- The “wobble” of the Earth’s axis, like a spinning top, over a 26,000yr. period.
- Axes point in different locations over time.
- Changes North/South Stars over time. (Vega, 14,000AD)
- This motion, along with changes in eccentricity and obliquity, affect long-term climate change and cause ice ages. (Milankovitch Cycles)

Precession


Perpendicular to ecliptic
Direction of Pole Star
Circle of precession
23½°
North Pole
Plane of the ecliptic
To the Sun
90°
Equator
South Pole

Precessionary path – 26K yr. cycle

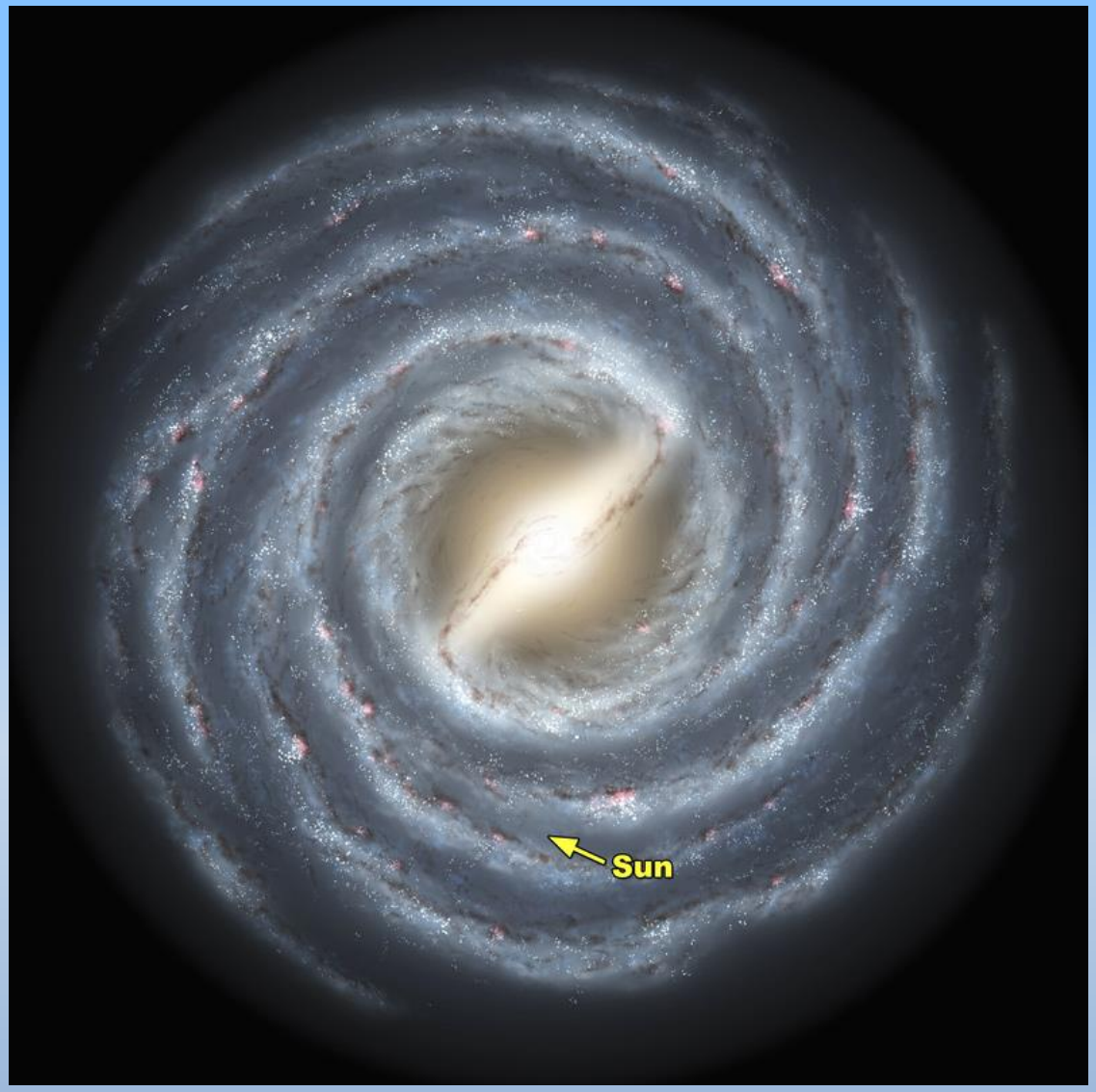


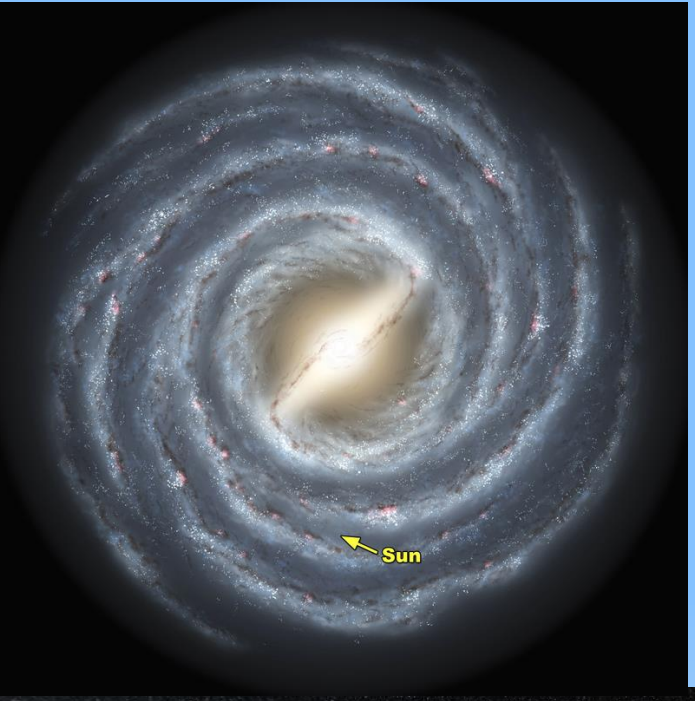
Other Motions – Interstellar & Intergalactic

- Sun (along with entire solar system) is moving in the direction of Vega @ 12.5mi/s
- The Sun and other nearby stars are revolving around the center of the Milky Way Galaxy at 155mi/s (one revolution takes 230 million yrs.)
- Milky Way Galaxy is moving in the direction of the neighboring Andromeda Galaxy, and will one day collide! (see wikispace for simulation)

Other Motions – Interstellar & Intergalactic

- **100,000 ly across**
- **Sun is ~ 3e4 ly from center of galaxy**
- **For Sun: 230,000,000 yrs. per revolution**





The Sun's Relative Motion

Other Motions – Interstellar & Intergalactic

http://www.youtube.com/watch?v=r-dtBfkzyl0&feature=BFa&list=PLBF5901F4CBCD6E0B

•Day on Earth

http://www.youtube.com/watch?v=IhqzW97_47w&feature=relmfu

•Year on Earth

http://www.youtube.com/watch?v=PWxcgJUCDxg

•SS True Motion

http://www.youtube.com/watch?v=uDsWD9QmwJ8&feature=BFa&list=PLBF5901F4CBCD6E0B

•Galactic Collisions

Lunar Motions!

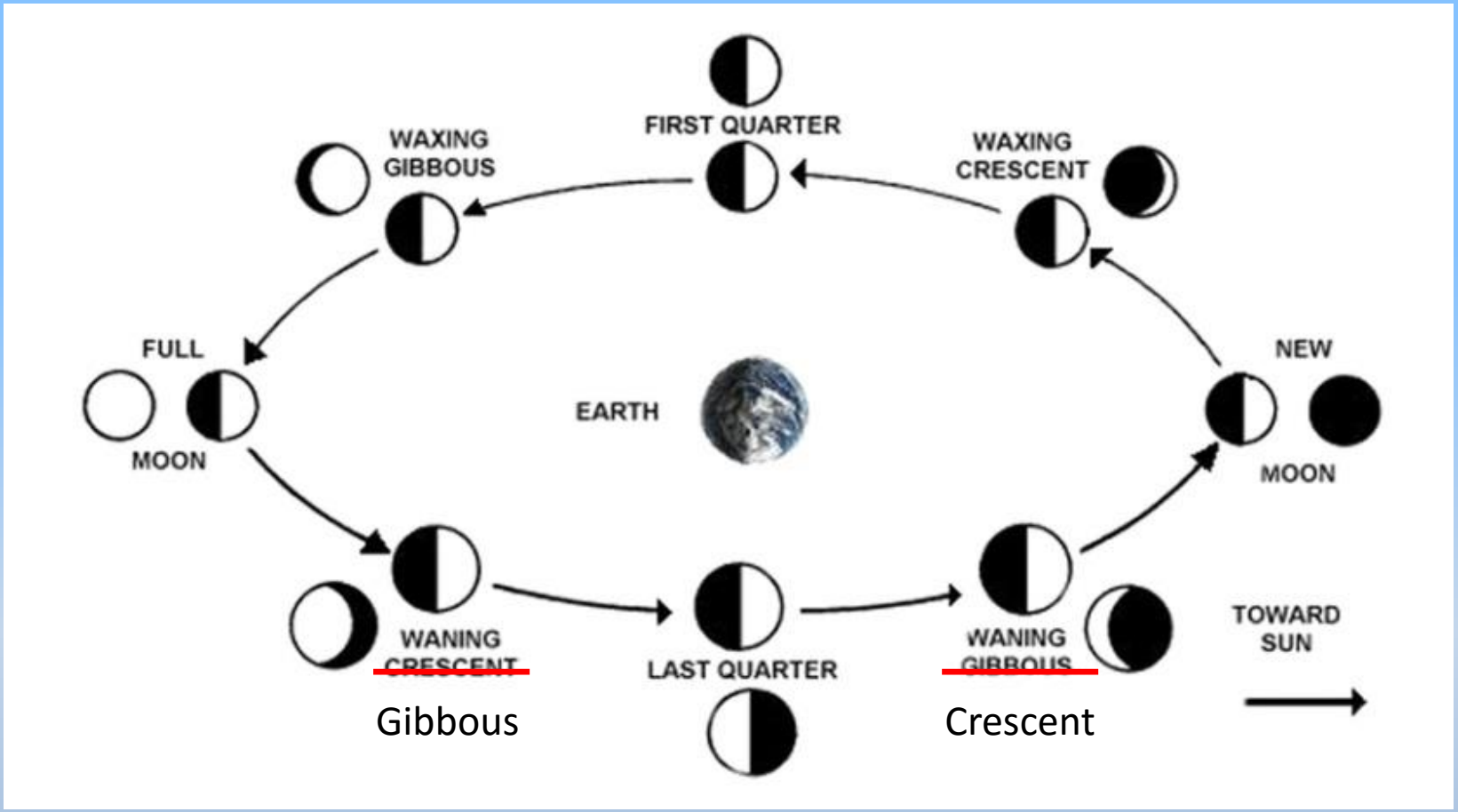
Lunar Motions Overview

- The moon takes about one **month** to orbit the Earth
- When the Earth-Moon system is viewed from above (looking down at the North Pole on Earth) the Moon orbits in a **counter clockwise** fashion.
- Like Earth's orbit around the Sun, the Moon orbit around Earth is **elliptical**, which causes variations in the Moon's **distance** from Earth.
- **Perigee** – The pt. at which the Moon is closest to Earth
- **Apogee** – The pt. at which the Moon is farthest from Earth
- Because the positions of the Earth, Moon and Sun change constantly with respect to each other, the Moon appearance as seen from Earth changes.

Lunar Phases

- The **phases of the Moon** are the changes in the amount of lit visible surface of the Moon we can see from Earth and are caused by the Moon's **revolution** around Earth.
- When the amount of lit surface of the Moon visible from Earth begins to increase daily, the moon is **waxing.**
- When the amount of lit surface of the Moon visible from Earth begins to decrease daily, the Moon is **waning.**
- The Moon can appear as a crescent, **gibbous, quarter,** full-moon or new moon.
- **Half** the moon is illuminated at any one time.
- During a **full-moon,** we see the entire lit surface of the moon and during the **new moon** phase we see none of the lit surface of the moon. In-between these phases, we can only see part of the lit surface of the moon.

Lunar Phases

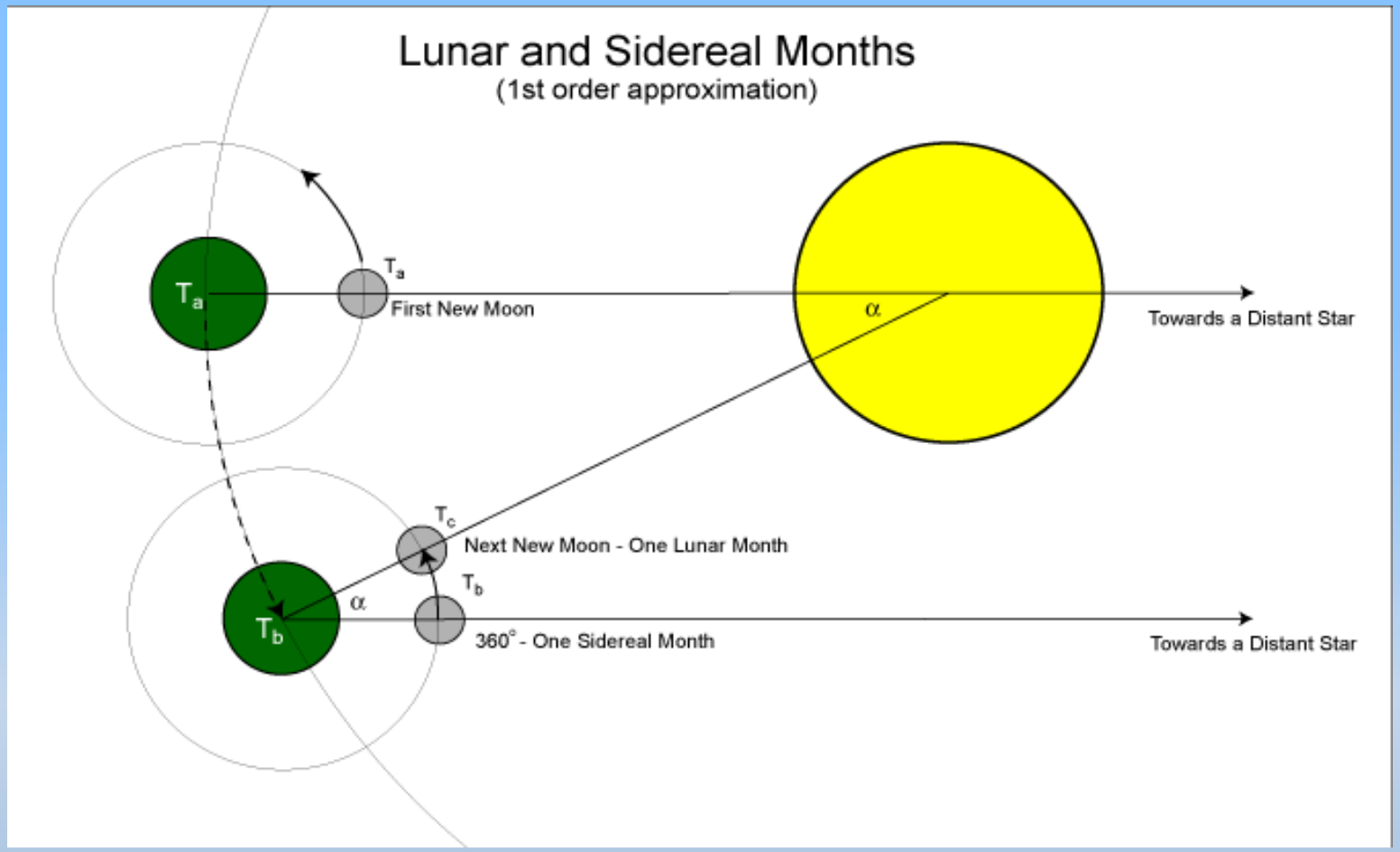


Tell me, what do you know about...

Lunar Time Periods

- There are two ways to measure the time it takes the moon to orbit the Earth:
  - **Synodic Month** – Time required for the moon to complete one cycle of phases (for ex. From new moon to new moon) 29.5 days., when the Earth and Moon realign with the Sun.
  - **Sidereal Month** – Time required for the moon to complete one *true* revolution around the Earth relative to a star other than the Sun – 27 1/3 days.
  - *Difference is caused by Earth's **revolution** around the Sun.

Lunar Time Periods



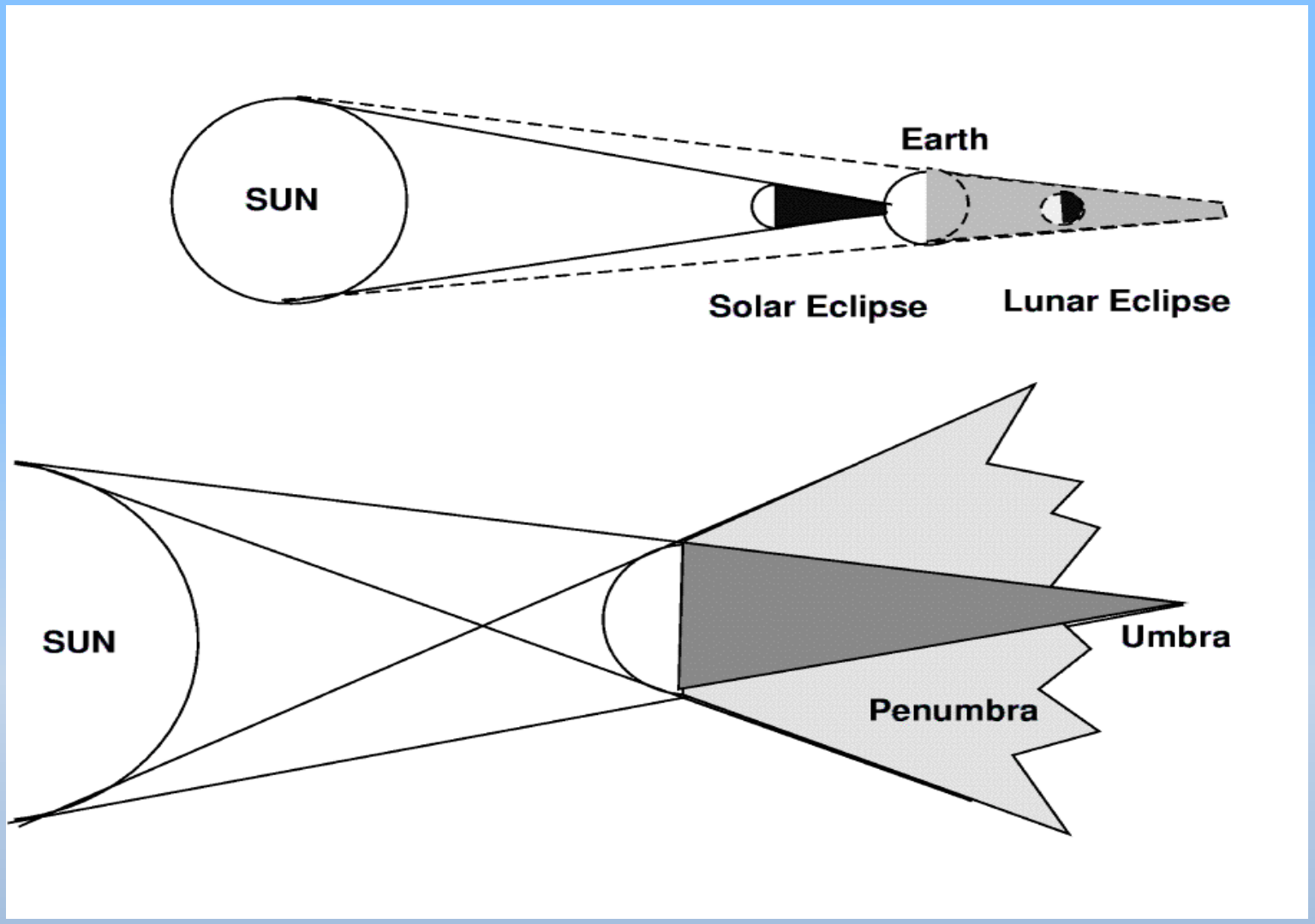
Lunar Time Periods

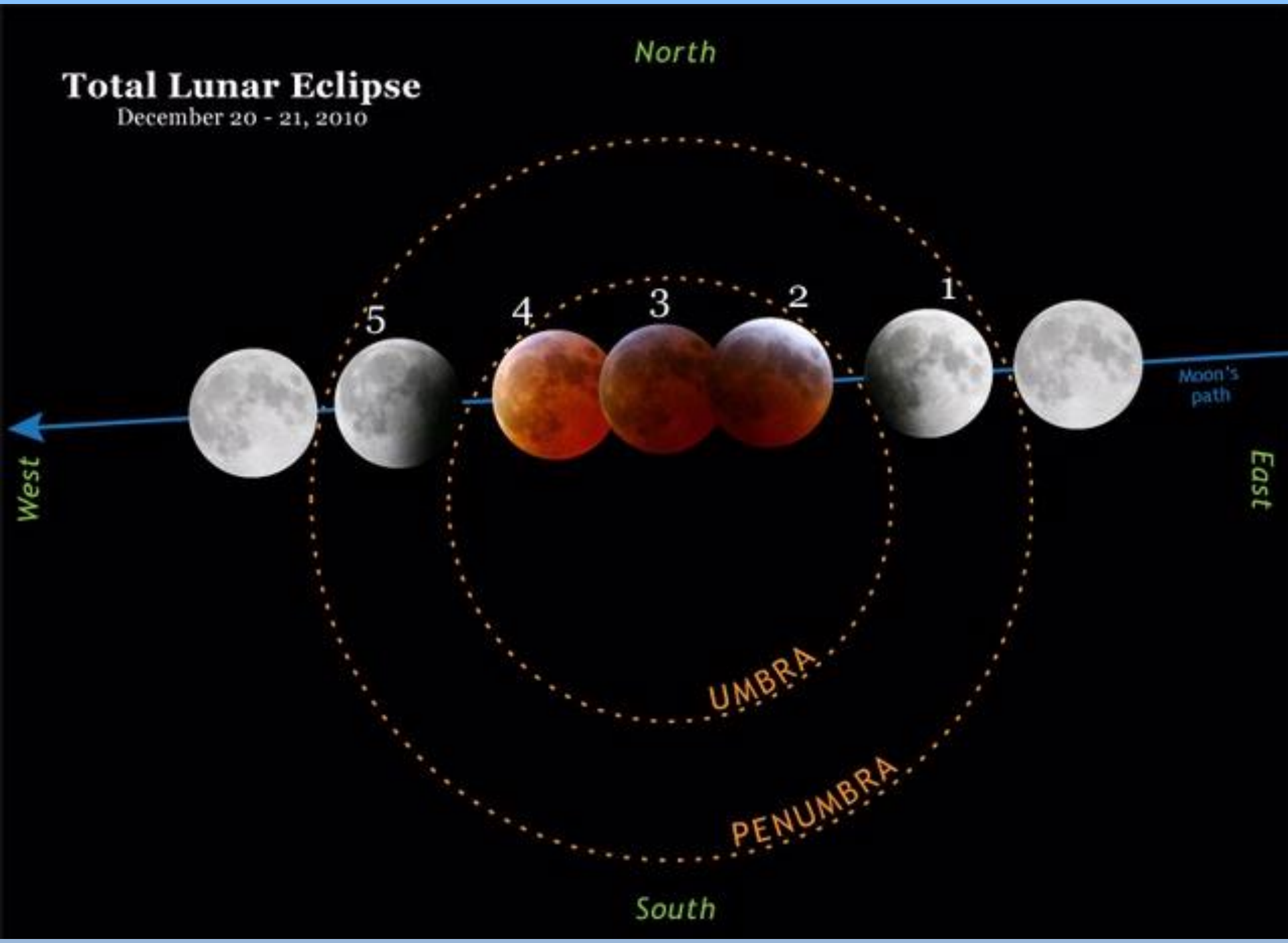
- *Synchronous Rotation* – The reason we always see the same side of the Moon. The moon **rotates** and **revolves** at the same rate, keeping one face towards us on Earth. The back side or "far side" is not seen by people on Earth and is much more densely **cratered**.
- The Moon rotates on its axis once every **27 1/3** days, so locations experience long periods of daylight and darkness (2 weeks), which makes for (along with the lack of atmosphere) extreme surface **temperature** differences (127°C or 260°F dayside, -173°C or -279°F night side)

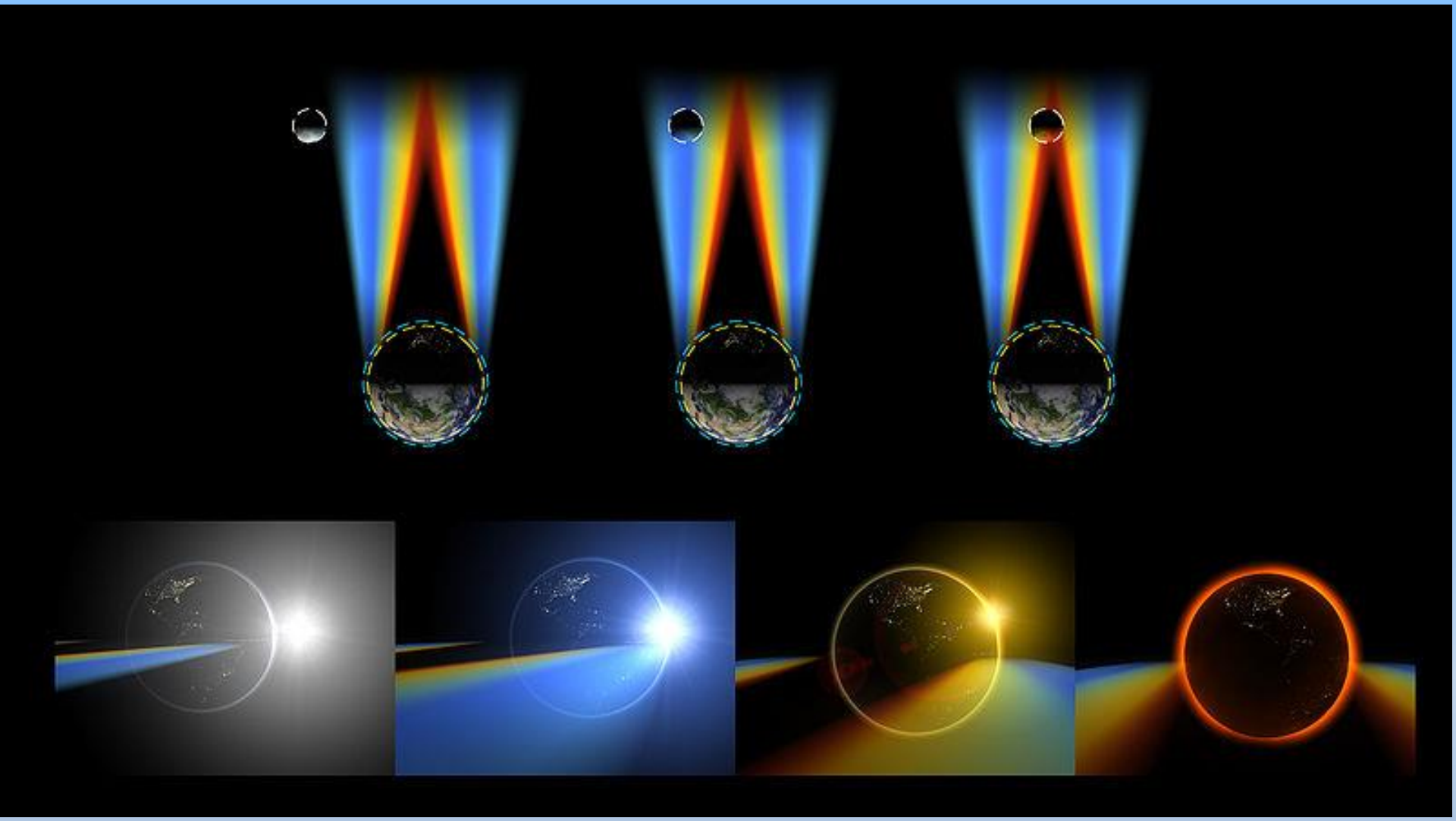
Eclipses

- Two types: **Lunar** and **Solar**
- A **lunar** eclipse occurs when the full moon moves through the shadow of Earth
- Earth's shadow always points **away** from the Sun and consists of two parts:
  - **Umbra** – region of total shadow (the dark part of the shadow)
  - **Penumbra** – region of partial shadow where sunlight is dimmed but not extinguished (lighter part of shadow)
- A total lunar eclipse occurs when the moon moves entirely into the **umbra** of Earth's shadow, and none of the moon is partially in the penumbra
- As seen from Earth, the moon moves the width of its diameter in the sky every hour – eclipse time can take up to 6 hours.
- Everyone on the **night** time side of can see a lunar eclipse.
- During a **total lunar** eclipse the moon will turn a coppery red color as the long red wavelengths of sunlight (which are not scattered by Earth's atmosphere) are refracted (bent) onto the lunar surface.

Eclipses



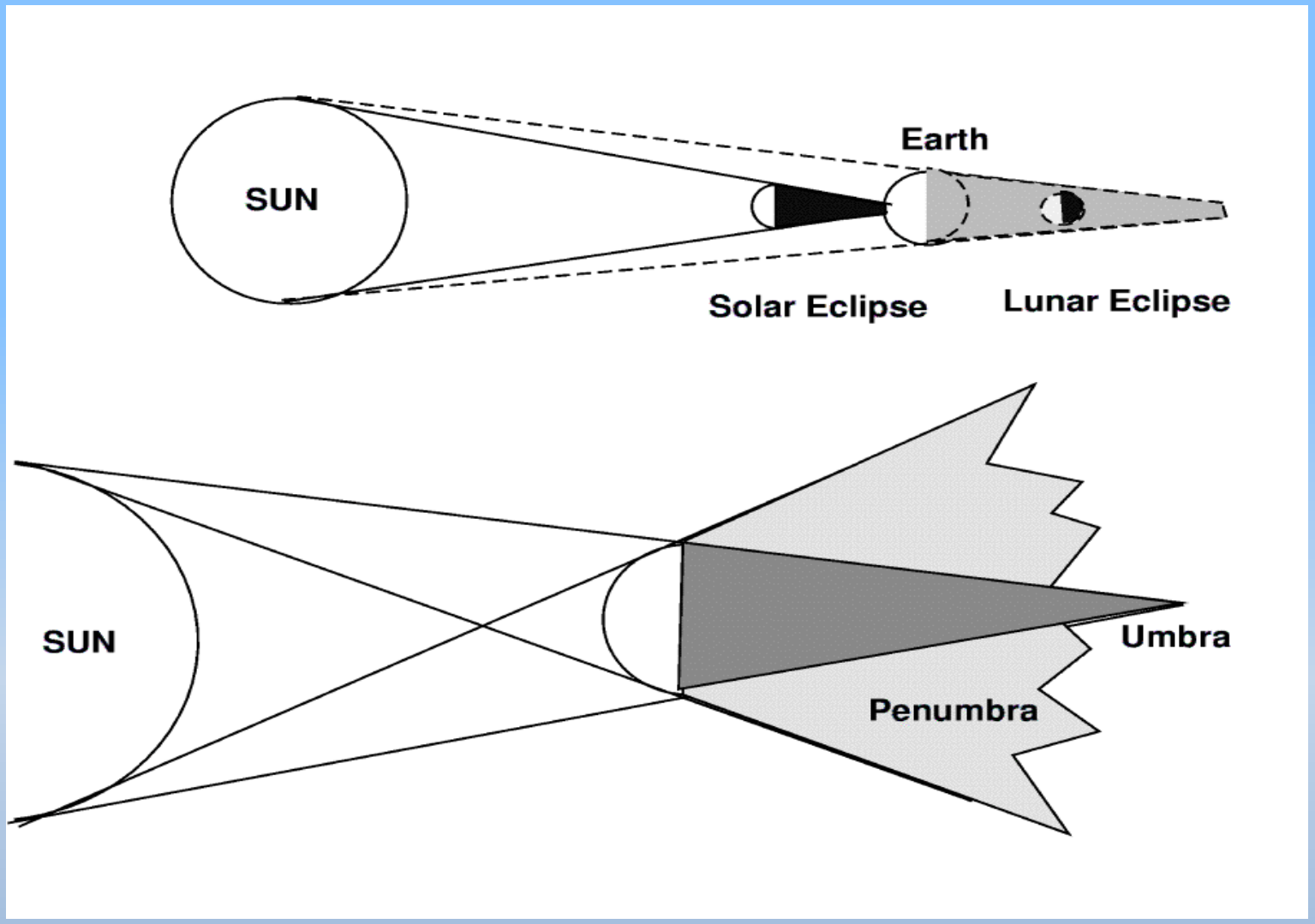

Total Lunar Eclipse
December 20 - 21, 2010
North
South
West
East
Moon's path
1
2
3
4
5
UMBRA
PENUMBRA

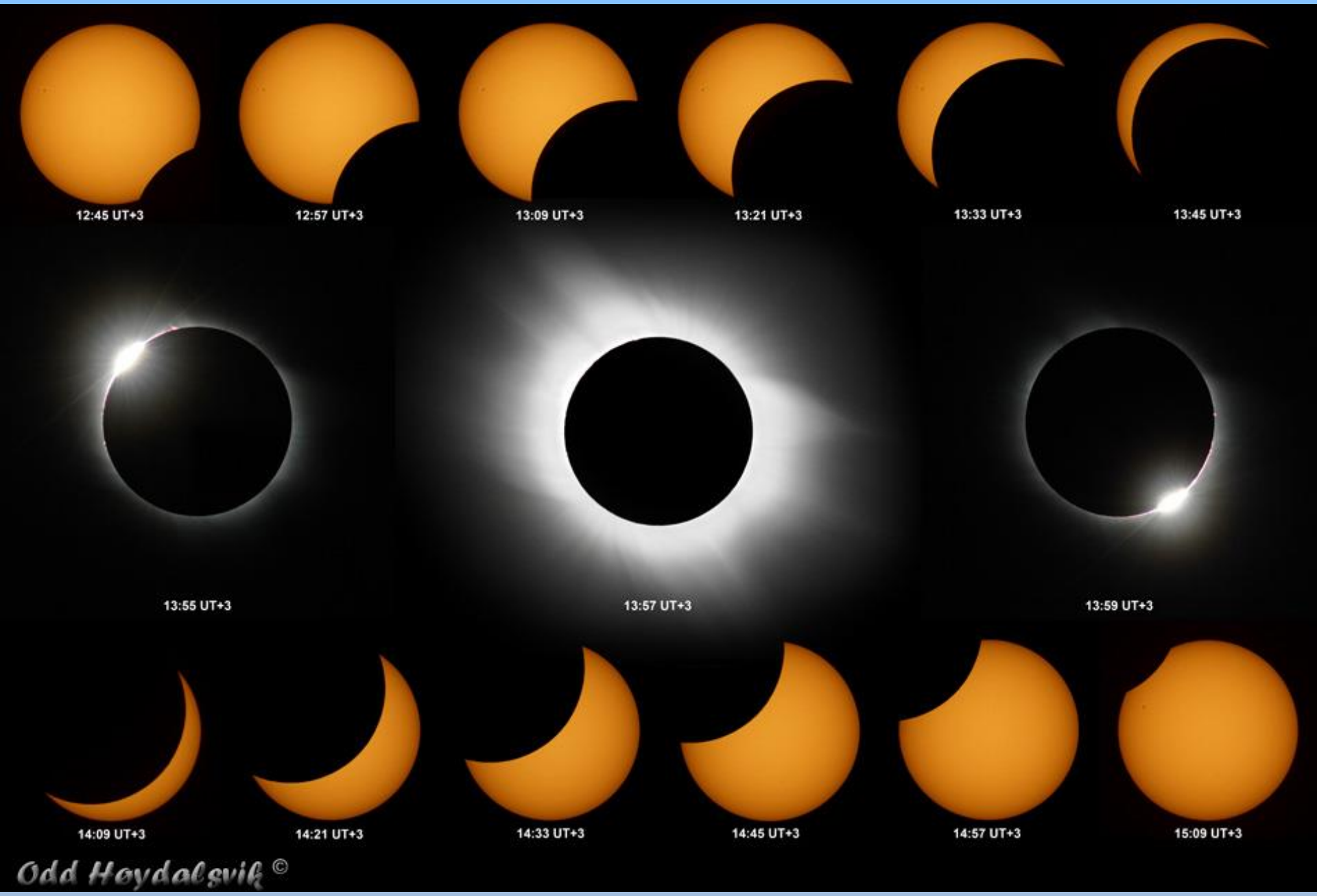


Eclipses

- **Solar** eclipses can occur because the Sun and Moon have the same angular diameter in the sky (.5°), so aligned correctly, the moon will either partially or totally block out the sun.
- The Sun is 400x larger than the moon, but also exactly **400x** further away from Earth than the moon – this is what makes the two objects the same size in the sky.
- Solar eclipses occur when the **moon** passes between the Sun and Earth.
- Not everyone gets to see a solar eclipse b/c the moon's shadow that falls on Earth is very **small** (only 167 miles wide) and moves quickly across Earth's surface (at least 1060mi/hr)
- *Totality* occurs when the sun is completely eclipsed by the moon and the bright photospheric layer is blocked out and the corona (faint outer atmosphere of sun) can be seen (totality lasts for no more than **8** min)
- Next solar eclipse visible in the US will be **Aug. 21, 2017.**
- Eclipses only occur during **full** or **new** moon phases.

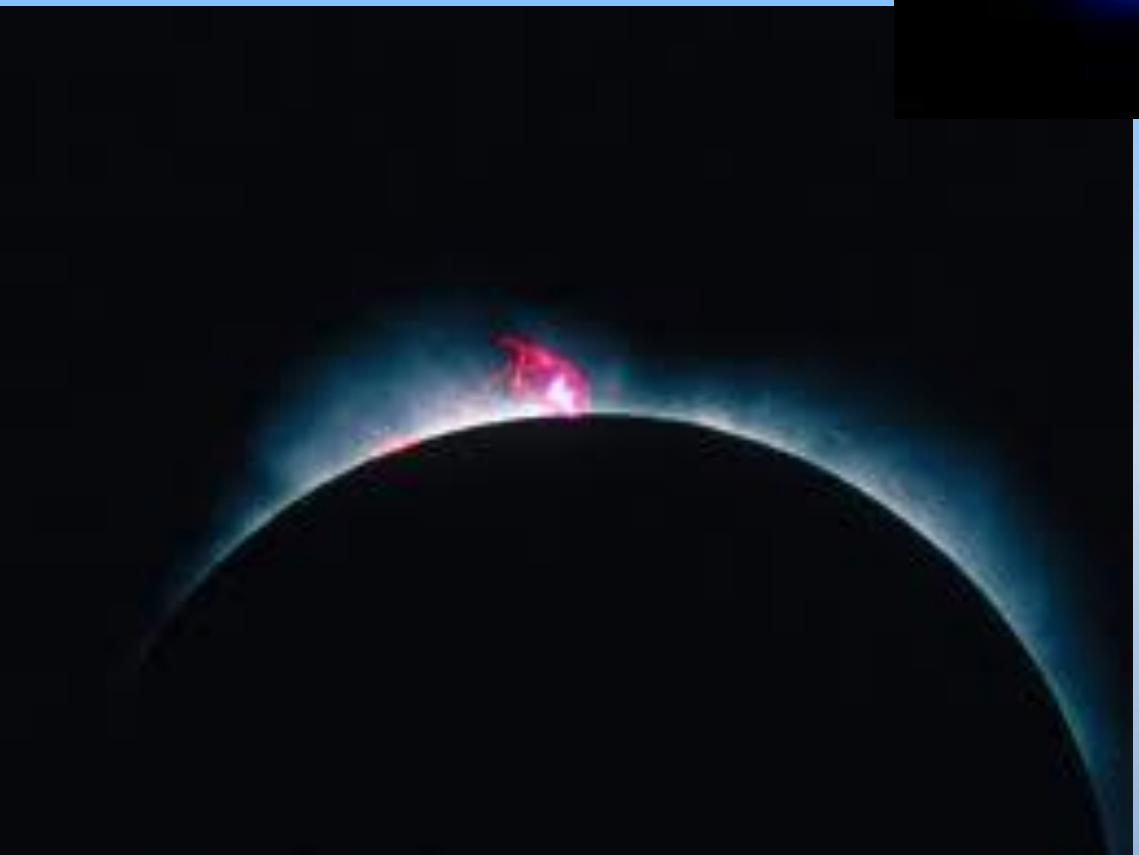
Eclipses



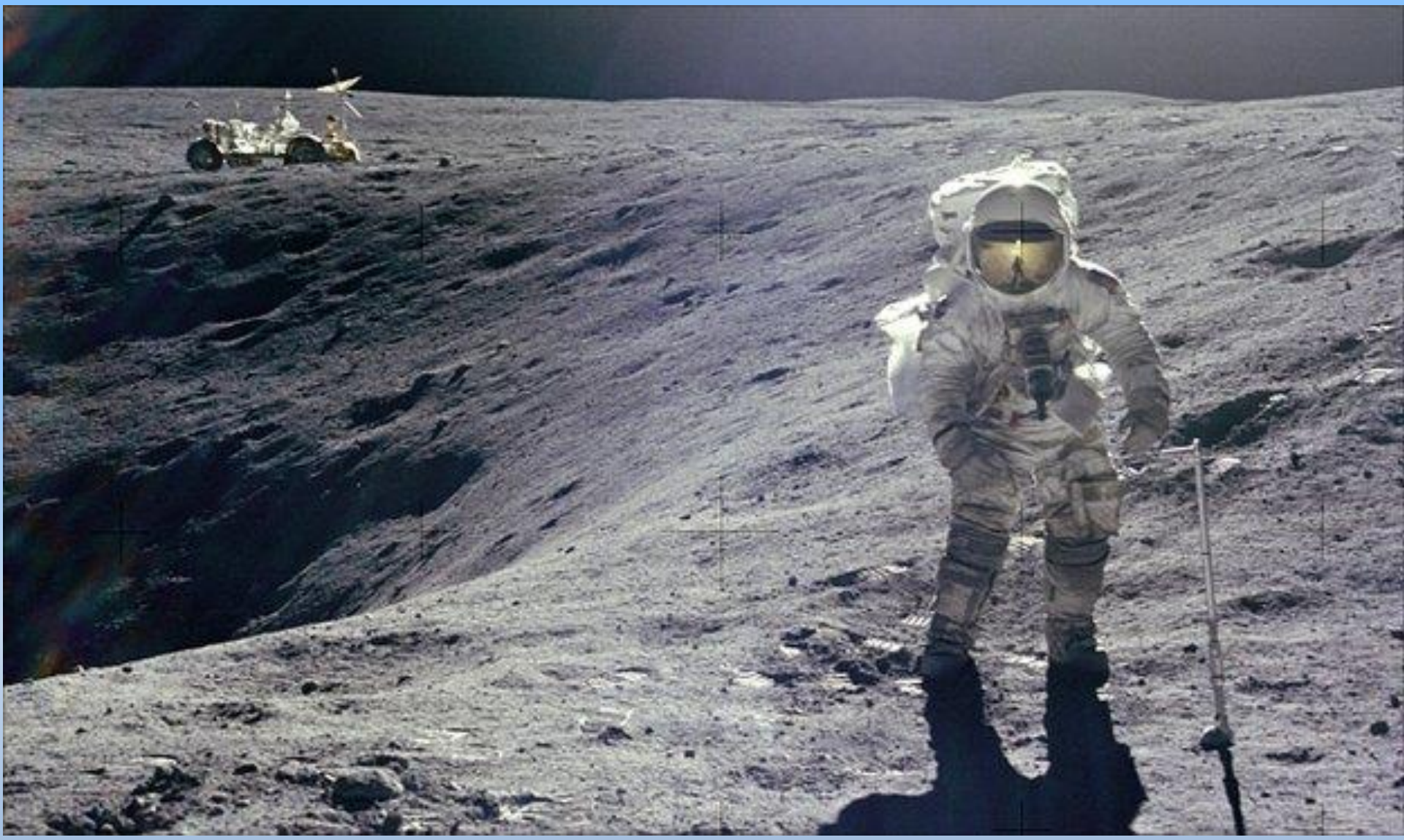

12:45 UT+3
12:57 UT+3
13:09 UT+3
13:21 UT+3
13:33 UT+3
13:45 UT+3
13:55 UT+3
13:57 UT+3
13:59 UT+3
14:09 UT+3
14:21 UT+3
14:33 UT+3
14:45 UT+3
14:57 UT+3
15:09 UT+3
Odd Høydalsvik ©

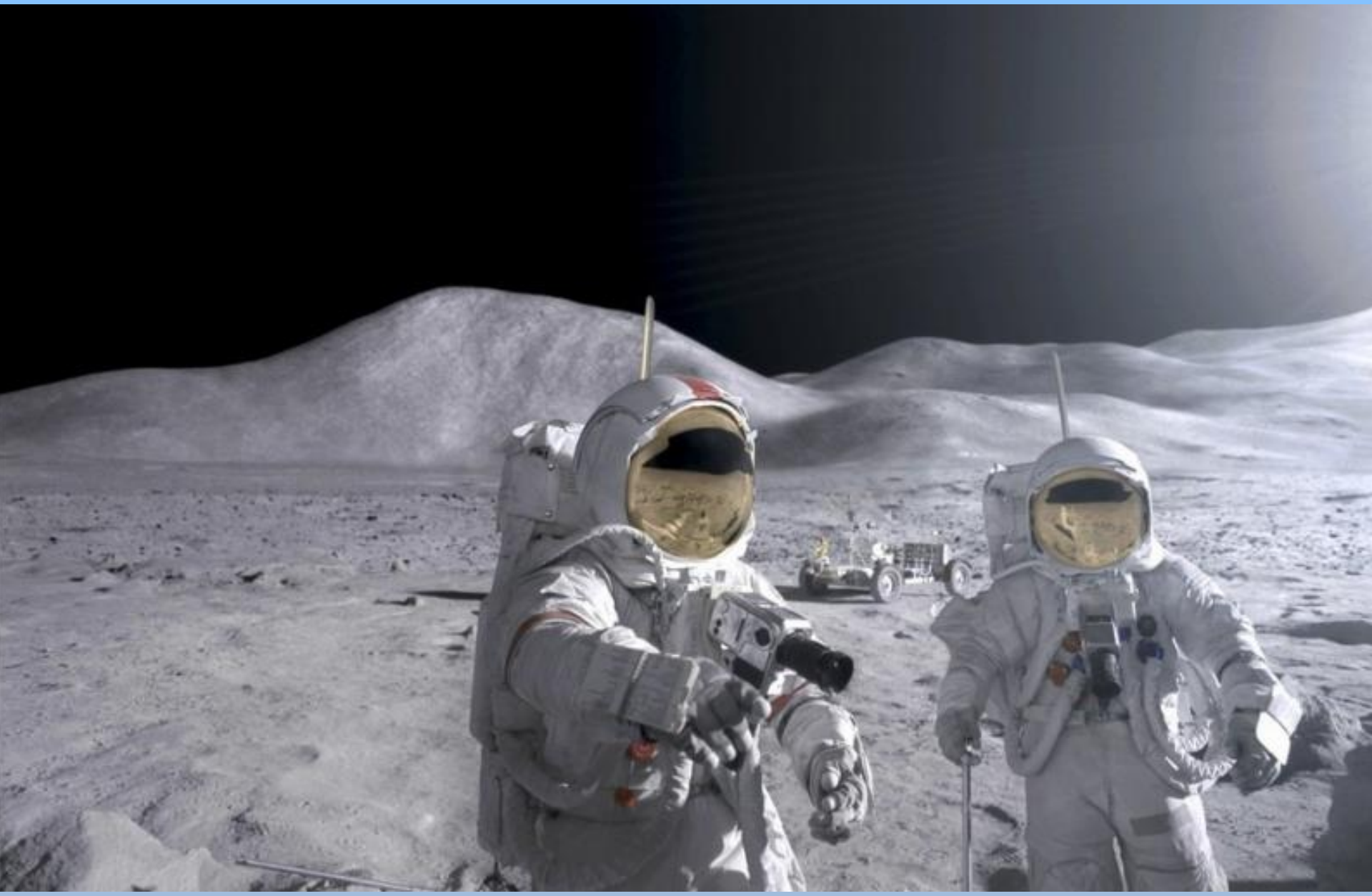
Eclipses

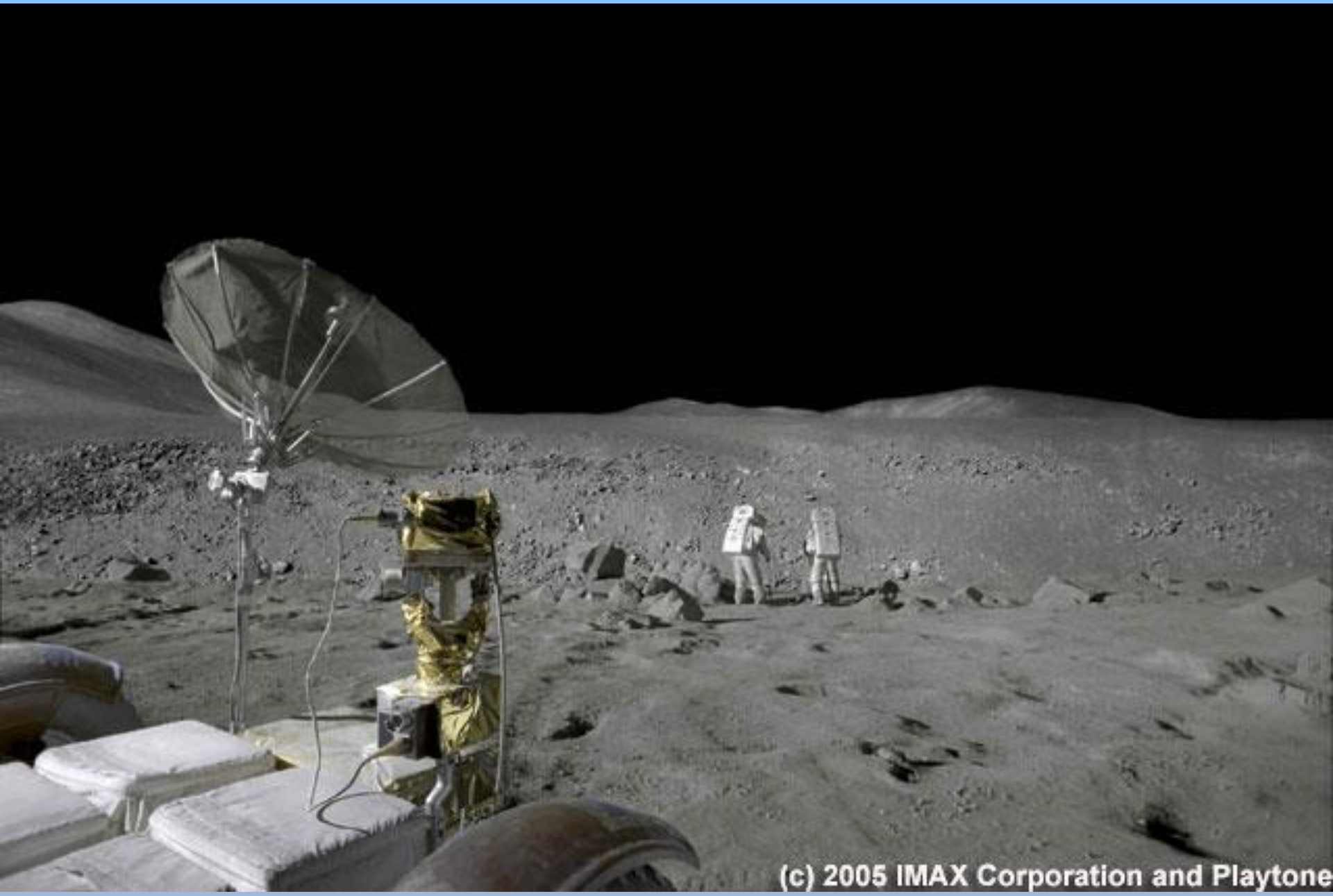
Seeing the Chromosphere!



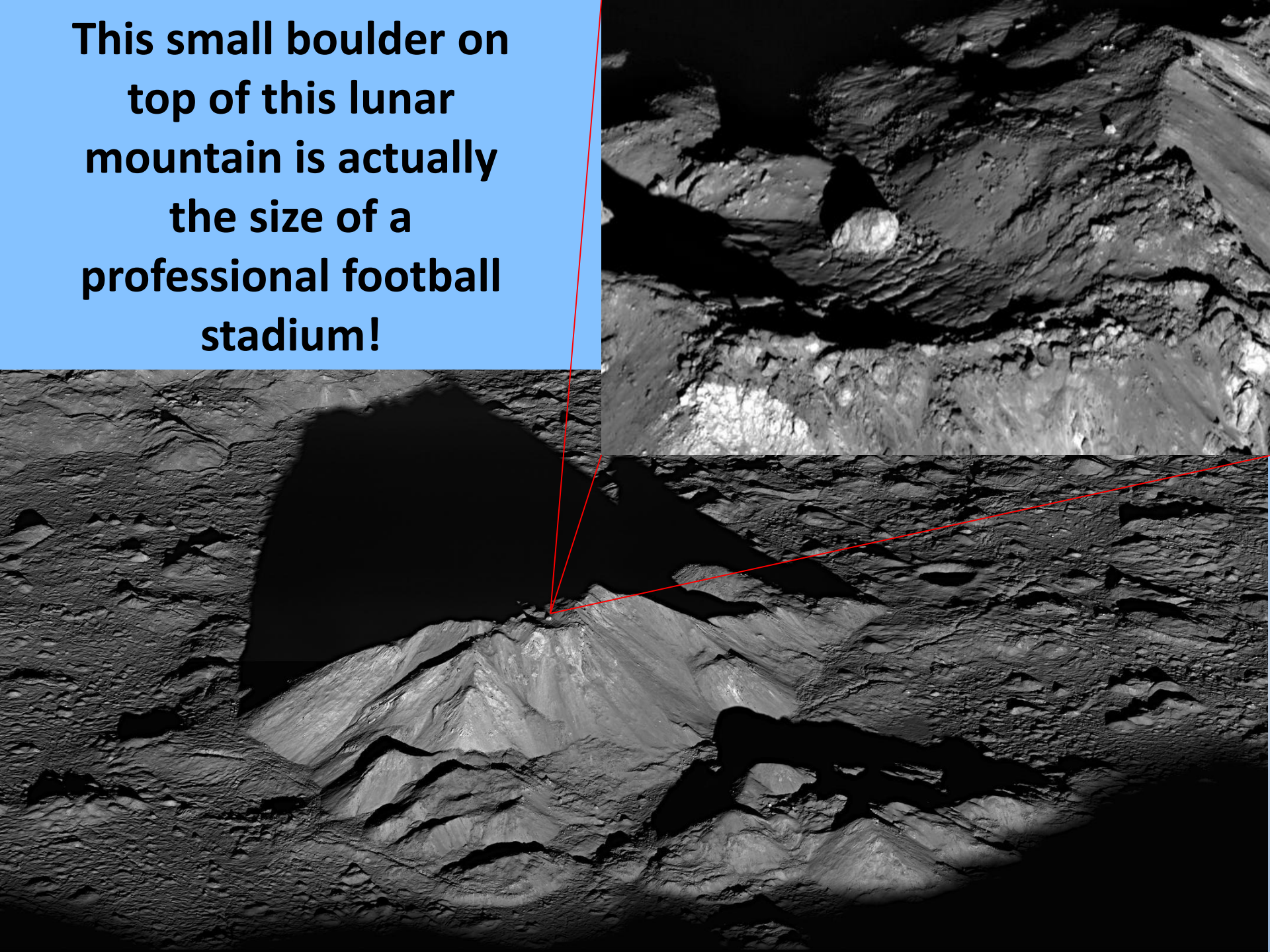
Lunar Surface/Origin

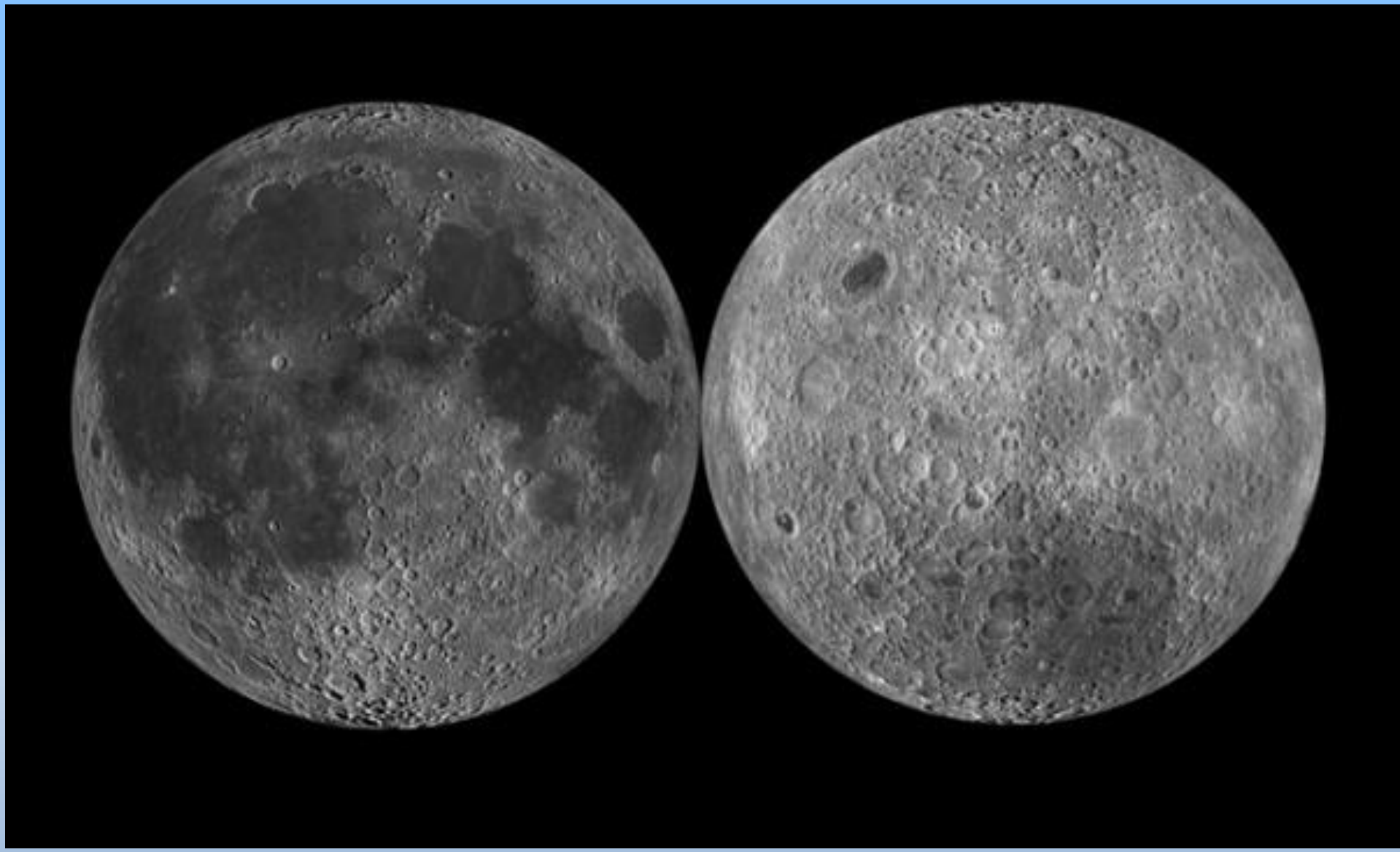


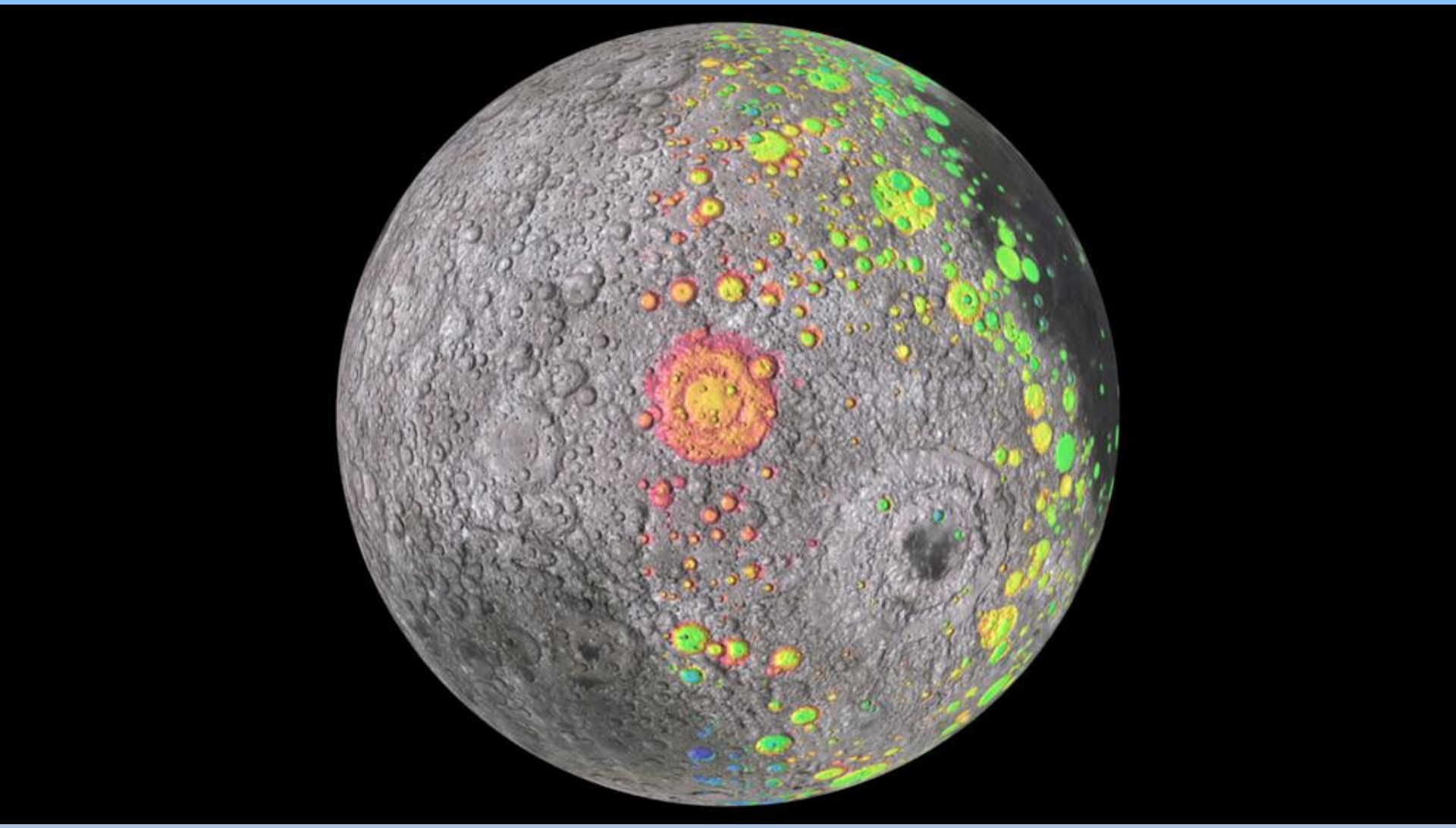


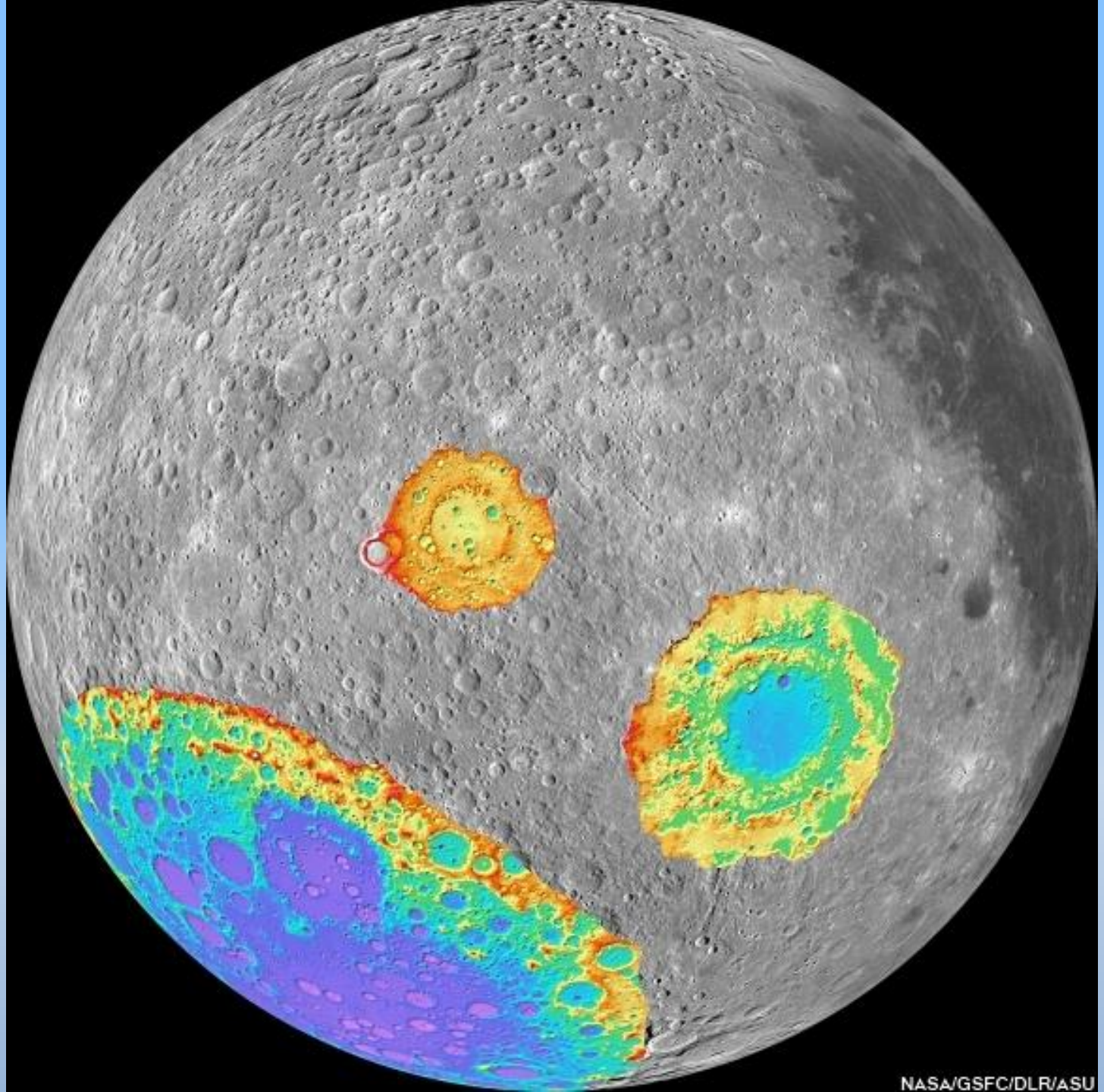

(c) 2005 IMAX Corporation and Playtone

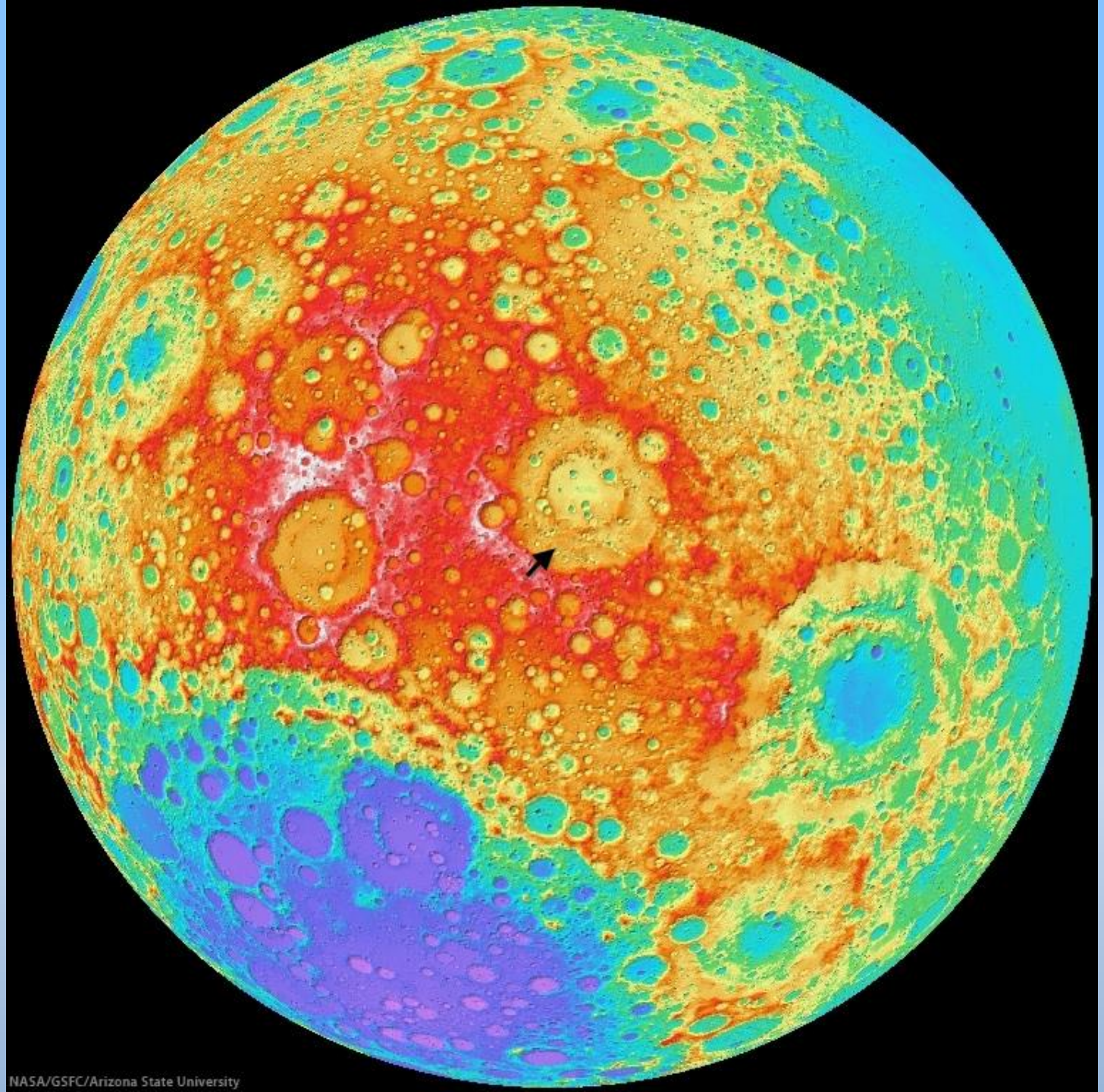
This small boulder on top of this lunar mountain is actually the size of a professional football stadium!








NASA/GSFC/DLR/ASU


NASA/GSFC/Arizona State University

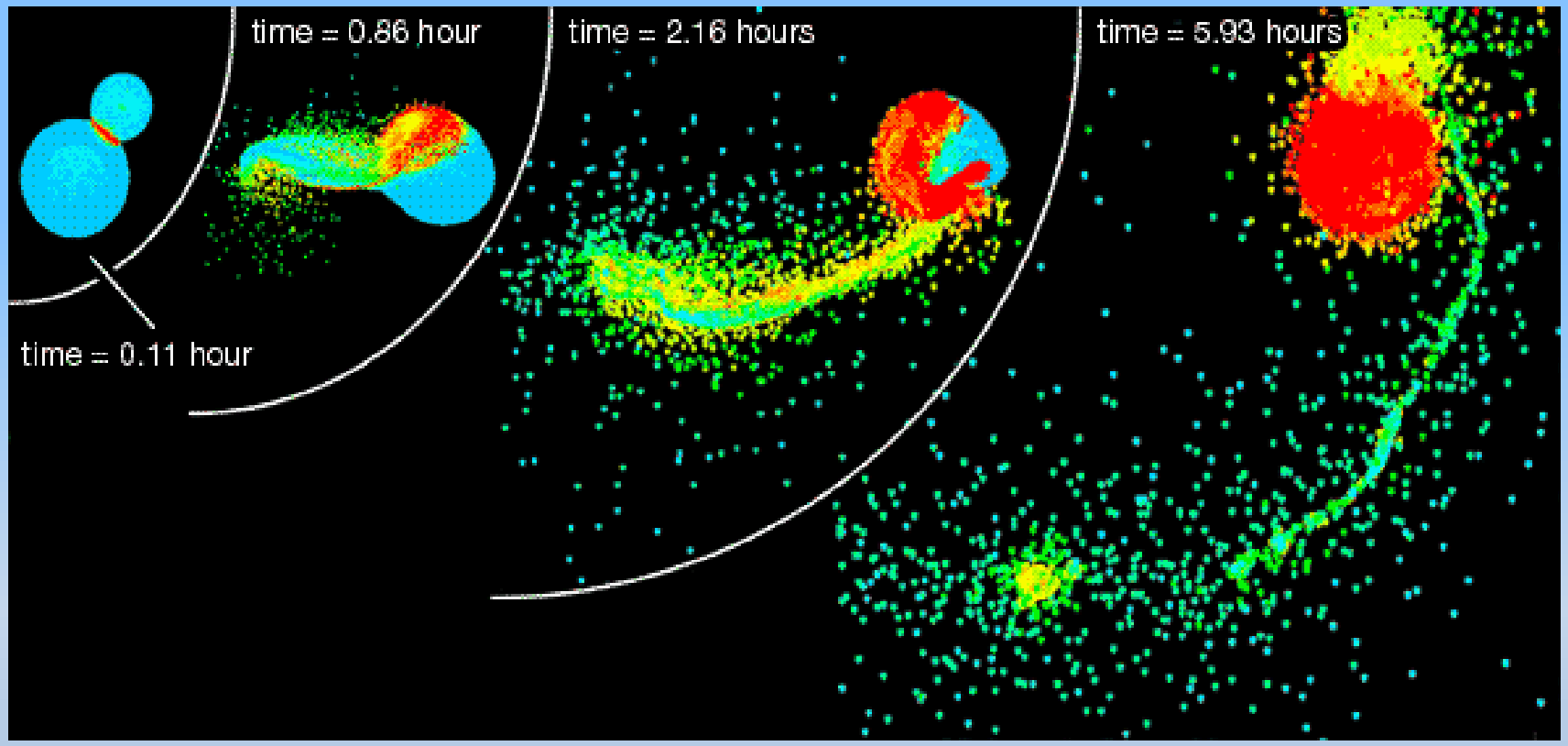
Lunar Surface

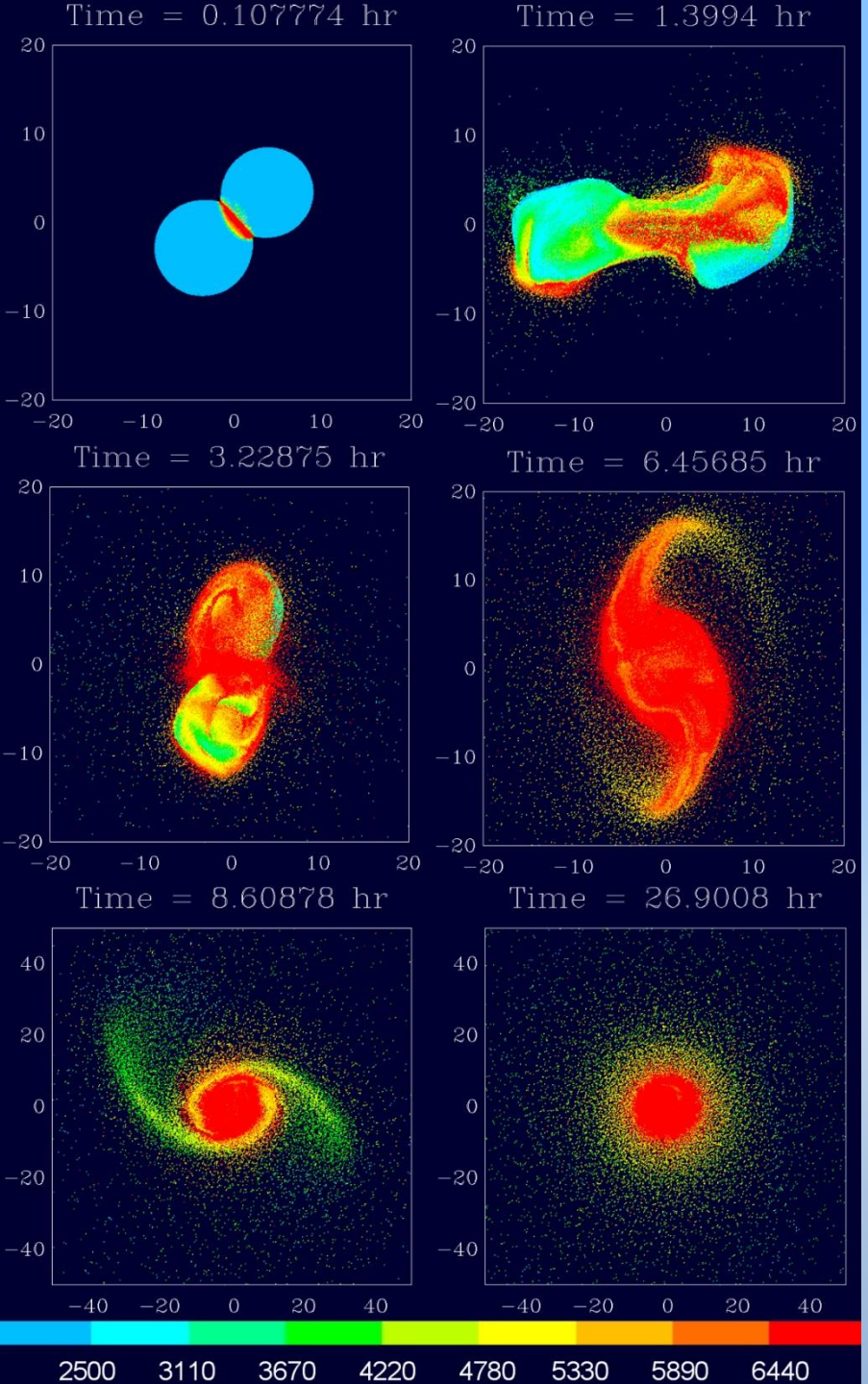
- Regolith – Lunar soil, fine powder – pulverized rock/glass.
- Maria – Dark areas on moon (seas), ancient basaltic lava flows resulting from large impacts, younger, relatively smooth – small fraction of lunar surface -20%
- Highlands – White lunar surface, oldest surface, mountainous & rugged – 80% of lunar surface
- Craters – circular depressions resulting from meteor impacts.
- Rays – “splash marks” around craters
- Extreme Temperatures & Radiation – Moon lacks an atmosphere so it gets very hot and very cold! Also, any incoming radiation will hit the surface – lunar surface looks “cooked”.

Lunar Origin:

- Early on in SS history, proto-Earth collided with another proto-planet the size of Mars
- Glancing (not head-on) blow, mostly mantle like material from Earth sprayed into space
- Smaller body mostly absorbed by remaining proto-Earth
- Orbiting mantle material coalesces into ball of mantle
- Both bodies eventually cool into the Earth and Moon.

Lunar Origins: Giant Impact Hypothesis (old)





Lunar Origins: Giant Impact Hypothesis (new)

http://phys.org/news/2012-10-moon-earth-like-composition-giant-impact.html

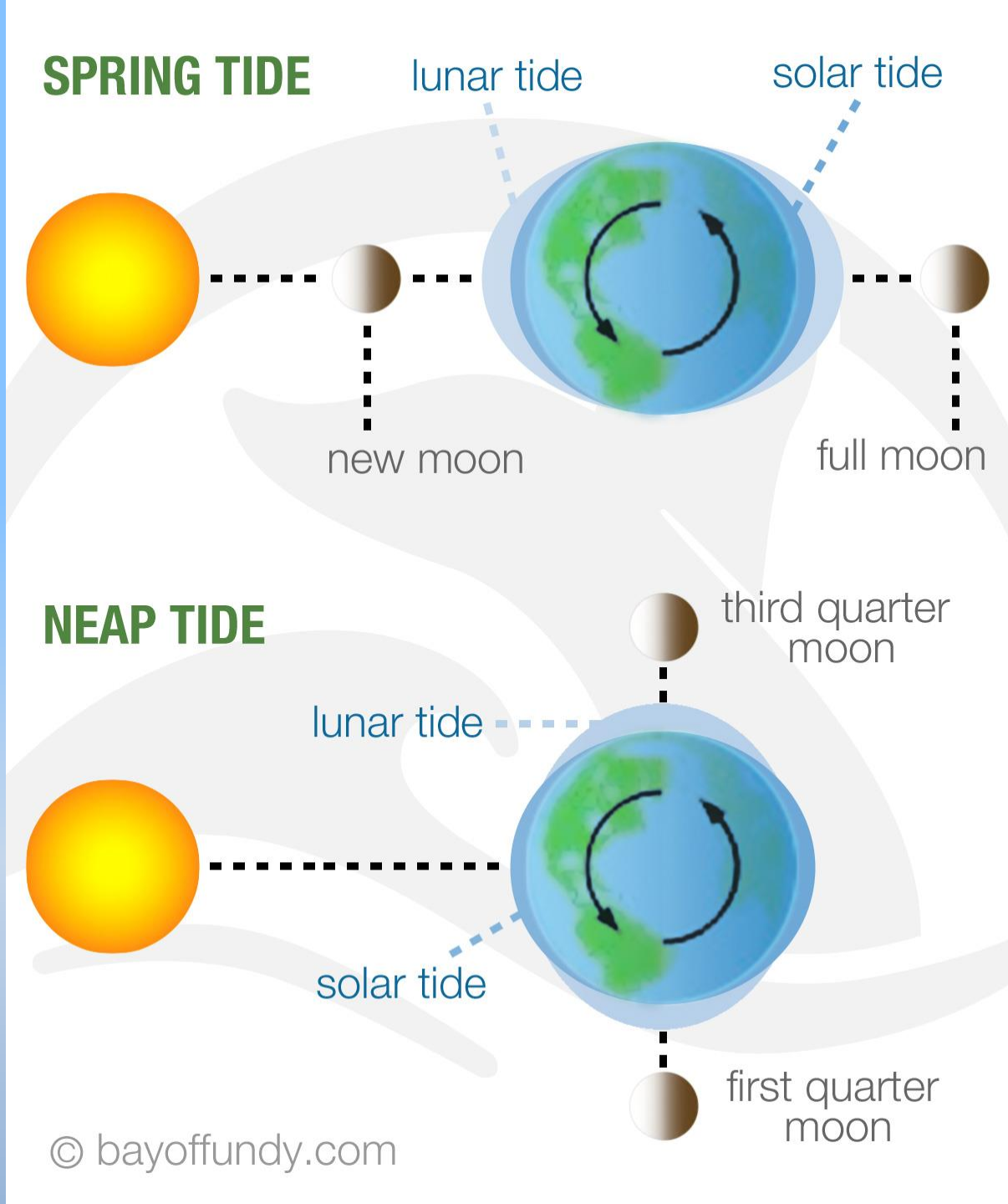
*See **Explorations reading "The Moon"** for great diagrams and pictures of the lunar surface. (on wikispace EMS System content page)

Going back to the Moon?

- YES! China & USA
- http://www.nasa.gov/exploration/home/index.html#.VPy5A_nF-So
- Moon is a stepping stone to Mars.
- By 2075, we will have likely built permanent outposts on the Moon.

Tides

- Tides refer to regular changes in the elevation or depth of areas within Earth's ocean waters caused by the gravitational pull of the moon and the sun.
- Water in Earth's oceans flows toward the Moon and forms a bulge.
- The Sun also creates tidal effects, but since the Sun is so much further away it doesn't pull on Earth's ocean waters with as much force as the moon (46% less)
- Two tidal bulges (areas of high tide) are created along the Earth-Moon line as the moon first pulls on the nearside ocean waters, and then also pulls the solid Earth away from the far-side ocean waters.


SPRING TIDE
lunar tide
solar tide
new moon
full moon
NEAP TIDE
third quarter moon
lunar tide
solar tide
first quarter moon
© bayoffundy.com

Tides

- Because the Earth rotates much faster than the moon revolves, positions on Earth are carried through the two tidal bulges (areas of high tide) and the two areas of low tide. Thus it is incorrect to say “the tide is coming in or going out” since we are actually rotating through deeper or shallower parts of Earth’s ocean.
- Tidal forces are strongest at New and Full Moon, when the gravitational pull from the Sun and Moon combine to create extreme high/low tides. These extreme tides are known as Spring Tides.
- During the quarter moon phases, the tidal forces of the Sun and Moon partially cancel each other – creating mild tides called Neap Tides.

Tides

- Land tides also occur, but the changes in elevation of land on Earth are imperceptible to us (< 8 inches/day). However, some places in our solar system experience extreme land tides, like on Io. Io is one of Jupiter's moons where the solid ground shifts more than 30 stories each day! That's over 300 ft.!
- Tidal forces are responsible for lengthening Earth's period of rotation (slowing Earth down), creating synchronous rotation and increasing the size of the moon's orbit around Earth. The moon is moving away from Earth at a rate of a centimeters/year.

- See pgs. 458-459 in the Pearson Textbook (online) for tides explanation
- Also in the Explorations “The Moon” reading pgs. 204-208